Appendix A: Annotated Bibliography of Peer Reviewed and other Technical Studies of SF Bay Delta Estuary, low salinity zone, and aquatic life.

This annotated bibliography is responsive to the first question the Board posed in the June 22, 2012 notice,[1] "What additional scientific and technical information should the State Water Board consider to inform potential changes to the Bay-Delta Plan relating to ecosystem changes and the low salinity zone that was not addressed in the 2009 Staff Report and the 2010 Delta Flow Criteria Report?"

Important Notes:

1. This is a live document continually being updated. EPA will provide updates to State Board staff as we complete them.
2. The information and citations listed below focus on ecosystem changes, low salinity zone, hydrology, flow, and aquatic life in estuaries and/or the Bay Delta estuary. They were published after or not referenced in the 2010 Flow Criteria Report.

2010

CAL. DEPT. OF FISH & GAME, QUANTIFIABLE BIOLOGICAL OBJECTIVES AND FLOW CRITERIA FOR AQUATIC AND TERRESTRIAL SPECIES OF CONCERN DEPENDENT ON THE DELTA (Nov. 23, 2010), available at http://www.dfg.ca.gov/water/water_rights_docs.html.

- Table 15: DFG Flow Criteria, pages 105-107, contains recommended flow criteria for aquatic life.
- Chapter 7, pages 32-93, contains useful information about aquatic habitat, flows, and life history traits of priority species including Chinook salmon, steelhead, longfin smelt, splittail, delta smelt, starry flounder, bay shrimp mysid shrimp, and American shad.

James A. Hobbs, JA, Lewis, L.S., Ikemiyagi N., Sommer, T, Baxter, R.T. (2010) The use of otolith strontium isotopes (87Sr/86Sr) to identify nursery habitat for a threatened estuarine fish. Environ Biol Fish (2010) 89:557–569 http://www.water.ca.gov/aes/docs/HobbsLongfin2010.pdf

- Low salinity habitats are important nursery areas for longfin smelt because they disproportionally contribute more longfin recruits (juveniles over a minimum size threshold) relative to both freshwater and brackish water habitats.
- The relative importance of the low salinity zone to successful recruitment appeared greatest in years following the longfin smelt population decline.

[1] Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/pubnot_phs2wrkshps.pdf

Mac Nally R, Thomson JR, Kimmerer WJ, Feyrer F, Newman KB, Sih A, Bennett WA, Brown L, Fleishman E, Culberson SD, Castillo G. 2010. An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling. Ecological Applications 20(5): 1417-1430.

- X2 and increased water clarity (reduced turbidity) were two factors affecting multiple declining fishes and their main zooplankton prey.
- Authors identify a strong relationship between Spring X2 and abundance of longfin smelt.
- Increases in water exports in both winter and spring were negatively associated with abundance of delta smelt and increases in spring exports with abundance of threadfin shad.

Nobriga, M.L. Bioenergetic modeling evidence for a context-dependent role of food limitation in California's Sacramento-San Joaquin Delta. California Fish and Game. Available at http://www.water.ca.gov/iep/docs/pod/NobrigaBioenergetic%20Modeling.pdf.

- Age-0 striped bass were less food limited than age-0 largemouth bass in recent years.
- Food limitation of age-0 striped bass occurs as a stressor interacting with other persistent stressors (e.g., high entrainment loss to water diversions) that all contribute to decreased habitat suitability.
- Rapid increases in habitat have facilitated largemouth bass population growth and are more important to largemouth bass' recent success than patterns of growth during the first year of life.

Thomson JR, Kimmerer WJ, Brown LR, Newman KB, Mac Nally R, Bennett WA, Feyrer F, Fleishman E. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20(5): 1431-1448.

- Abiotic variables, including water clarity, X2, and the volume of freshwater exported from the estuary, explained some variation in species' abundances over the time series, but no selected covariates could explain statistically the post-2000 change points for any species.
- Species-specific, covariate-conditioned change point models show abrupt declines of delta smelt and longfin smelt in 2004 and of striped bass and threadfin shad in 2002.
- Water clarity and winter exports both had high probability of inclusion and a negative effect on delta smelt; water clarity and spring X2 had high probability of inclusion for longfin smelt.

York J, Costas B, McManus G. 2010. Microzooplankton grazing in green water—results from two contrasting estuaries. Estuaries and Coasts 34: 373-385.

- The authors found many instances of saturated and insignificant grazing of phytoplankton by microzooplankton in San Francisco Bay.
- Saturation in some cases may result from high particle loads.
- Insignificant grazing may result from extreme saturation of the grazing response due to the need to process non-food particles.
- There was no evidence of nutrient limitation for phytoplankton growth.
- The authors found increasing phytoplankton growth rates and microzooplankton grazing rates with increasing salinity in the spring and summer of 2007.

- Grazing rates in San Francisco Bay and Long Island Sound were similar to those found in other estuaries.

2011

Frederick Feyrer et al., Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish, ESTUARIES & COASTS (2011) 34: 120-128, available at http://www.springerlink.com/content/d22u618x244n7j46/fulltext.pdf.

- The quantity and quality of the delta smelt habitat index (salinity and turbidity) decreased by 78% between 1967 and 2008. A key part of the concern for delta smelt is that the lowest levels of suitable habitat coincide with the habitat being located further upstream in closer proximity to anthropogenic sources of mortality such as water diversions and certain contaminant sources.
- Locations of LSZ downstream of the confluence of the Sacramento and San Joaquin rivers results in a dramatic increase in the habitat index, when the LSZ encompasses the expansive Suisun and Grizzly Bays, a larger area of suitable habitat.
- Food density, entrainment risk, predation risk, and exposure to contaminants are habitat elements affected by salinity and turbidity which must be present for smelt to use the habitat.
- Increased habitat area is likely to reduce any density-dependent effects on the delta smelt population.
- Delta smelt will face serious threats if water demand increases and climate change projections are realized.

Maunder, M.N, and R.B. Deriso. 2011. A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (Hyposmesus transpacificus). Canadian Journal of Fisheries and Aquatic Sciences 68:1285–1306.

- An annual multistage life cycle model was created in which the number of individuals in the first life stage (e.g., delta smelt larvae) is determined by the number of individuals in the last stage of the previous year (delta smelt adults that reproduced).
- The state-space model is used to numerically describe the transition from one life stage to the next.
- Several factors thought to impact abundance were evaluated including entrainment, food abundance, temperature, predator abundance, and turbidity. Although exports were identified as an important factor, they were assumed to be related to entrainment.
- Results indicate that, of the parameters included, food abundance, temperature, predator abundance, and density dependence are most important in controlling the population dynamics of delta smelt.

Schoellhamer DH. 2011. Sudden clearing of estuarine waters upon crossing the threshold from transport to supply regulation of sediment transport as an erodible sediment pool is depleted: San Francisco Bay, 1999. Estuaries and Coasts 34: 885-899

- Changes in the San Francisco Bay ecosystem in the 2000s have been symptomatic of sudden sediment clearing.

- A statistically significant 36% step decrease in SSC in San Francisco Bay from water years 1991–1998 to 1999–2007.
- Depletion of an erodible sediment pool in 1999 would cause a sudden decrease in SSC.
- Supply of hydraulic mining sediment increased bed sediment volume by at least 260 Mm^3 in the late 1800s, almost entirely in Suisun and San Pablo Bay.

Winder M, Jassby AD. 2011. Shifts in zooplankton community structure: implications for food web processes in the upper San Francisco Estuary. Estuaries and Coasts 34: 675-690.

- Increased water diversion at times of decreased water availability exacerbated the effects of post-1960 droughts by further reducing freshwater inflow.
- Amplifying outflow reductions during a drought increased drought severity and allowed unusually extreme salinity intrusions and invertebrate invasions.
- These conditions intensified benthic grazing on native invertebrates allowing invasive invertebrates to colonize.

2012

EPA convened a Technical Workshop on Estuarine Habitat in the Bay Delta Estuary on March 27, 2012 ("2012 EPA Workshop") to discuss and advance understanding in the scientific community about the relationship between the low salinity zone, salinity gradient, and the abundance of fish species. EPA worked with Aquatic Science Center and other partners to produce a number of resources relevant to the Board's review of the Bay-Delta Plan.

- San Francisco Bay Delta Estuarine Habitat Workshop Agenda (PDF) (5 pp, 319K)
- Review of San Francisco Bay Delta Estuary Low Salinity Zone Scientific Papers and Summary of Key Findings (PDF) (30 pp, 424K)
- Description of Estuarine Habitat, Low Salinity Zone, and X2 Models (PDF) (14 pp, 836K)
- Notes on Estimating X2 with DAYFLOW (PDF) (5 pp, 405K)
- Data for Notes on Estimating X2 with DAYFLOW (.XLSX) (738K)
- Salinity and flow in Northern San Francisco Bay: Physics and Modeling (SUNTANS) (PDF) (12 pp, 993K) -- Stephen Monismith
- Modeling Estuarine Habitat using the UnTRIM Bay-Delta Model (PDF) (28 pp, 1.22M) -- Michael MacWilliams
- Historical Perspectives on the Estuarine Gradient (PDF) (27 pp, 4.71M) -- Robin Grossinger
- Low Salinity Zone Workshop Summary (PDF) (69 pp, 1.57 MB)

Workshop materials are available at the hyperlinks provided in the above list and at the EPA SF Bay Delta website www.epa.gov/sfbaydelta/activities. Scroll down and click on Sacramento-San Joaquin Delta Water Quality Standards to reveal the collapsed list identical to the one above.

Miller, W.J., B.F.J. Manly, D.D. Murphy, D. Fullerton, and R.R. Ramey. 2012. An investigation of factors affecting the decline of delta smelt (Hypomesus transpacificus) in the Sacramento-San Joaquin Estuary. Reviews in Fisheries Science 20:1-19.

- Authors used the Ricker population abundance model and initial quantification of factors they determined to have a direct impact on delta smelt abundance (Figure 2, page 5).
- Identifies prey density as the most important environmental factor explaining variations in delta smelt abundance from 1972 to 2006 and over the recent period of decline.
- Delta smelt entrainment at south Delta pumping plants had an impact on adult-to-juvenile survival but not over the fish's life cycle.
- Fall X2 did not explain delta smelt population trends beyond those accounted for by prey density.

NRC (National Research Council). 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC.

- A thorough discussion regarding the development and use of X2 as an indicator of estuarine organism abundance and as a regulatory tool to protect aquatic life (see pages 53 – 60).
- Mechanisms explaining the impact of X2 on abundance of a variety of biota remain hypothetical.
- However, statistical relations reported in several papers show that abundance of a number of species at different trophic levels found in the Delta and San Francisco Bay is higher when X2 is lower (farther downstream).
- This implies that reductions in outflow would tend to reduce the abundance of these organisms.